General Approach to Report Writing

1 Scope

This document provides a guideline for reporting results for examiners who issue reports in the Trace Evidence Unit and Scientific and Biometrics Analysis Unit – Trace.

2 Procedures

2.1 It will not always be possible to adequately summarize analytical findings using only the examples provided here. It is acceptable to use other wording when the following conditions are met:

- the results of the examinations are accurately communicated,
- a description of the methodology used to reach the results is included,
- known limitations are addressed,
- the most current version of the applicable *FBI Approved Standards for Scientific Testimony and Report Language and Department of Justice Uniform Language for Testimony and Reports are* followed, and
- the wording is approved by a second examiner who is qualified in the discipline during the technical review process.

2.2 The *Laboratory Report* will be prepared and formatted in accordance with requirements set forth in the FBI Laboratory Operations Manual (LOM) - *Practices for Preparing, Reviewing, and Issuing Laboratory Reports and Retaining Records for Legacy Cases* or the *Practices for Preparing, Reviewing, and Issuing Laboratory Reports and Retaining Records in Forensic Advantage (FA)*.

2.3 The report will include a description of the methods used in analysis. Examples of appropriate wording for the methods used are included in Appendix A. If no examinations were conducted, then no methods section is required.

2.4 The **Results of Examinations** section will be used to communicate the results of the trace evidence examinations. Examples of appropriate wording for the **Results of Examinations** section are included in Appendix B.

2.4.1 If applicable, interpretations/limitations will be included and will be used to communicate any known limitations of the results, and/or limitations of the testing based on the evidence received. This information can be included in the **Results of Examinations** section or can be a separate section. This material will include any interpretations that may aid the reader in understanding the significance of the **Results of Examinations**. Examples of appropriate wording for the interpretations/limitations are included in Appendix C. If no examinations were conducted, then no interpretations/limitations section is required.

2.5 At a minimum, the **Remarks** section will provide the information required by the LOM - *Practices for Preparing, Reviewing, and Issuing Laboratory Reports and Retaining Records for Legacy Cases* or the *Practices for Preparing, Reviewing, and Issuing Laboratory Reports and Retaining Records in Forensic Advantage (FA)*.

3 References

- FBI Laboratory Operations Manual
- FBI Approved Standards for Scientific Testimony and Report Language for the Microscopic Examination of Hairs (current version)
- FBI Approved Standards for Scientific Testimony and Report Language for the Microscopic Examination of Fibers (current version)
- FBI Approved Standards for Scientific Testimony and Report Language for the Forensic Anthropology Discipline (current version)
- FBI Approved Standards for Scientific Testimony and Report Language for Forensic Geologically-derived Materials Examinations (current version)
- FBI Approved Standards for Scientific Testimony and Report Language for Forensic Glass Examinations (current version)
- Department of Justice Uniform Language for Testimony and Reports for the Forensic Textile Fiber Discipline (current version)
- Department of Justice Uniform Language for Testimony and Reports for the Forensic Hair Discipline (current version)
- Department of Justice Uniform Language for Testimony and Reports for the Forensic Anthropology Discipline (current version)
- Department of Justice Uniform Language for Testimony and Reports for the Forensic Geology Discipline (current version)
- Department of Justice Uniform Language for Testimony and Reports for the Forensic Glass Discipline (current version)

Rev. #	Issue Date	History
4	02/03/2020	Updated name of SBAU-Trace in Scope. Removed 'Introduction.' Added The Department of Justice Uniform Language for Testimony and Reports to Section 2.1 and to references. Updated Sections 3.3 and 3.4.1 regarding no exams being conducted. Added Section 3 on alternate reporting.
5	05/03/2021	Changed category of testing to discipline throughout. Updated report form numbers in Section 3. Removed section on Alternate Reporting. Updated language in Appendix B for hair inclusions and soil inclusions. Updated language in Appendix C for anthropology examinations.

Redacted - Signatures on File

Approval

Trace Evidence Unit Chief: Date: 04/30/2021

Scientific and Biometrics Analysis Unit Chief: Date: 04/30/2021

Hairs and Fibers Technical Leader: Date: 04/30/2021

Geology Technical Leader: Date: 04/30/2021

Anthropology Technical Leader: Date: 04/30/2021

QA Approval

Quality Manager: Date: 04/30/2021

Appendix A: *Examples of Appropriate Wording for the Methods used in a Trace Evidence Report*

Example of a hair examination and comparison:

Microscopic examination of hairs is accomplished by using stereomicroscopy and comparison microscopy. The presence or absence, appearance, arrangement and distribution of the characteristics within the cuticle, cortex, and medulla of the hairs are examined and may be compared during a hair examination.

Example of a fiber examination and comparison:

Microscopic examination of textile fibers is accomplished by using one or more analytical techniques including stereomicroscopy, comparison microscopy, polarized light microscopy, fluorescence microscopy, and instrumentally using microspectrophotometry and Fourier transform-infrared spectroscopy. The microscopic characteristics and optical properties determined by these techniques are used for the examination and comparison of fibers.

Example for a cordage examination and comparison (used in conjunction with fiber method):

Cordage examinations are accomplished through visual and microscopic examination of the cordage construction and the fibers comprising that cordage.

Example for a fabric examination and comparison (used in conjunction with fiber method):

Fabric examinations are accomplished through visual and microscopic examination of the fabric construction and the fibers comprising that fabric.

Example for a fabric physical match:

Physical matching of fabrics is accomplished through a visual examination of the damaged edges of two or more pieces of fabric. Damaged edges are characterized and compared macroscopically and using a stereomicroscope to determine if the pieces of fabric were previously one continuous item.

Example for a cordage physical match:

Physical matching of cordage is accomplished through a visual examination of the damaged edges of two or more pieces of cordage. Damaged edges are characterized and compared macroscopically and using a stereomicroscope to determine if the pieces of cordage were previously one continuous item.

Example of a glass examination and comparison:

Comparison of glass items for the purposes of determining the possibility of a common origin is accomplished by using one or more analytical techniques. These techniques include:

- Examinations of fracture surfaces for fractography are conducted using stereobinocular and/or compound microscopes.
- Determination of physical properties such as glass type, glass color, and thickness. The physical properties of the glass are determined using stereobinocular and petrographic microscopes, micrometers, and ultraviolet lights.
- Measurement of the refractive index at up to three wavelengths, 488 nm, 589 nm, and 656 nm. Refractive index of the glass is measured using the Foster + Freeman, Ltd. Glass Refractive Index Measuring system (GRIM3).
- Determination of the concentrations of aluminum, barium, calcium, iron, magnesium, manganese, sodium, strontium, titanium, and zirconium. The elemental concentrations are determined using a ThermoFisher iCAP 6500 Duo inductively coupled plasma - optical emission spectrometer (ICP-OES).

The actual tests performed are dependent on the size and shape of the glass fragments, and analytical requirements. When a difference is found between compared items, the examination may be immediately discontinued. For this case, a fractography examination was conducted between glass recovered from the debris from the cottage wall east (Item 1) and the windshield of the Formula Powerboat (Item 5).

Additionally, a comparative glass examination was conducted between the glass recovered from the vicinity of the cottage (Item 2 through Item 4) and the glass from the windshield of the Formula Powerboat (Item 5). The physical properties expressed in the glass were determined using stereobinocular and petrographic microscopes. Multiple measurements of refractive index at 589 nm wavelength and of the concentrations of the ten above listed elements were acquired.

Example of a geologically-derived materials examination and comparison:

Comparison of geologically-derived materials for the purposes of determining the possibility of a common origin is accomplished by using one or more analytical techniques. These techniques can include:

- Color designation: Determination of the color of the material. This may be accomplished unaided, or by using Munsell Soil Color Charts in a light box under day light conditions.
- Textural analysis: Determination of texture using stereobinocular and petrographic microscopes.
- Composition determination: Identification of components present and their relative proportions using stereobinocular and petrographic microscopes or additional instrumental methods, as needed.

The actual tests performed are dependent on the type(s) and quantity of the geologically-derived material present, and the needs of the examination/analytical requirements. When a difference is found between compared items, the examination may be immediately discontinued.

In this case, the items were examined for color using a using a light box and Munsell Soil Color Charts, and for texture and composition using stereobinocular and petrographic microscopes.

Example of an anthropology examination:

The techniques used for anthropological analyses typically include visual (morphoscopic) examination, metric analysis (*i.e.*, measuring bones and performing calculations), microscopic examination, or radiologic examination. The actual tests performed are dependent on the quality and quantity of skeletal material present, and the needs of the examination or analytical requirements.

In this case, the items were examined visually, microscopically, metrically, and radiologically.

Appendix B: *Examples of Appropriate Wording for the Results of Examinations Section of a Trace Evidence Report*

Example of a hair examination and comparison:

Inclusion:

A head hair that exhibits characteristics of European ancestry recovered from Item 1 is microscopically consistent with hairs in the head hair sample from {Name} (Item 5). Accordingly, based on the Item 5 head hair sample, {Name} can be included as a possible source of this hair. This hair has been designated as Item 1-1 for possible mitochondrial DNA analysis.

The comparison of microscopic characteristics in hairs does not constitute a basis for personal identification and the number of individuals who could be included as a possible source of a specific hair is unknown. The inclusion of an individual as a possible source of the hair by comparison of microscopic characteristics should be evaluated in conjunction with the DNA analysis report(s) [lab number w/ case record #] dated [date of DNA report(s)].

Inconclusive:

Similarities and Differences
A head hair that exhibits characteristics predominantly of European ancestry recovered from Item 2 exhibits both similarities and differences to hairs in the head hair sample from {Name} (Item 5). Accordingly, based on the Item 5 head hair sample, no conclusion can be reached as to whether or not {Name} can be included as a possible source of this hair. This hair has been designated as Item 2-1 for possible mitochondrial DNA analysis.

Similar but limited
A head hair that exhibits characteristics of African ancestry and is of limited value for microscopic comparison purposes was recovered from Item 3. This hair is microscopically similar to hairs in the head hair sample from {Name} (Item 5). However, due to the limited nature of this hair, no conclusion can be reached as to whether or not {Name} can be included as a possible source. This hair has been designated as Item 3-1 for possible mitochondrial DNA analysis.

Exclusion:

Head hairs that exhibit characteristics of Asian or Native American ancestry recovered from Item 4 are microscopically dissimilar to hairs in the head hair samples from {Name} (Item 5) and {victim Name} (Item 6). Accordingly, based on the Items 5 and 6 head hair samples, {Name} and {victim Name} cannot be included as possible sources of these hairs.

Examples of a fiber examination and comparison:

Inclusion:

Three green polyester fibers found on Item 3 exhibit the same microscopic characteristics and optical properties as the fibers comprising Item 1. Accordingly, these fibers are consistent with originating from the Item 1 shirt, or another source comprised of fibers that exhibit the same microscopic characteristics and optical properties.

No other apparent transfer of textile fibers was detected between Items 1 and 2 and Items 3 and 4.

OR

Green polyester fibers recovered from under the tape in Item 1 exhibit the same microscopic characteristics and optical properties as the green polyester fibers recovered from under the tape in Item 2. Accordingly, these fibers are consistent with originating from the same source, or different sources comprised of fibers that exhibit the same microscopic characteristics and optical properties.

Inconclusive:

Three fibers recovered from Item 2 and the fibers comprising Item 3 do not exhibit sufficient observable microscopic characteristics or optical properties to perform a full fiber examination and comparison. Accordingly, no conclusion can be reached as to whether or not these fibers are consistent with originating from the same source.

Example for a fabric examination and comparison:

Inclusion:

The black fabric in Item 1 exhibits the same color, construction, and composition as the black fabric in Item 2. Accordingly, the piece of black fabric in Items 1 and 2 are consistent with originating from the same source or from two sources with the same color, construction, and composition.

Example for a cordage examination and comparison:

Inclusion:

The brown thread in Item 3 exhibits the same color, construction, and composition as the brown thread in Item 1. Accordingly, the lengths of brown thread in Items 1 and 3 are consistent with originating from the same source or from two sources with the same color, construction, and composition.

Example for a fabric physical match:

Inclusion:

The pieces of fabric in Item 1 and Item 2 physically match together. Accordingly, the pieces of fabric were once one contiguous piece of fabric.

Example for a cordage physical match:

Inclusion:

The pieces of rope in Item 1 and Item 2 physically match together. Accordingly, the pieces of rope were once one contiguous piece of rope.

Example of a glass examination and comparison:

Fracture Fit:

Item 1 physically fits together with a piece of glass from the windshield of the Formula Powerboat (Item 5). Consequently, the piece of glass recovered from the debris from the cottage wall east (Item 1) was once part of the windshield of the Formula Powerboat (Item 5) (a fracture fit, see interpretation section, below).

Inclusion:

Glass recovered from the vicinity of the cottage (Item 2) is indistinguishable from glass from the windshield of the Formula Powerboat (Item 5). Consequently, the glass from the vicinity of the cottage (Item 2) either originated from the windshield of the Formula Powerboat (Item 5) or from another source of broken glass indistinguishable in all of the measured or observed physical properties, refractive index, and elemental composition (an inclusion, see interpretation section, below).

Inconclusive:

Debris recovered from the vicinity of the cottage (Item 3) contains glass fragments that are too small for analysis. No conclusions can be reached as to whether or not these glass fragments could have originated from the windshield of the Formula Powerboat (Item 5) (inconclusive, see interpretation section, below).

Exclusion:

Glass recovered from under the rear of the cottage (Item 4) is compositionally different than the glass from the windshield of the Formula Powerboat (Item 5). Consequently, the glass recovered from under the rear of the cottage (Item 4) did not originate from the windshield of the Formula Powerboat as represented by Item 5 (an exclusion, see interpretation section, below).

Example of a soil examination and comparison:

A soil comparison was conducted between soil recovered from the shoes (Items 1 through 4), and the soil from various locations (Item 7 and Item 8), and between debris recovered at the grave site (Item 5) and a brick from the residence (Item 6).

Fracture Fit:

The debris recovered from the grave site and the brick from the residence (Items 5 and 6, respectively) are each broken pieces of a brick. The brick piece recovered from the grave site (Item 5) physically fits together with the broken brick from the residence (Item 6). Consequently, the brick piece recovered from the grave site (Item 5) was once part of the brick from the residence (Item 6) (a fracture fit, see interpretation section, below).

Inclusion:

Soil recovered from the debris from the shoes (Items 1 and 2) cannot be differentiated from the soil from the dirt road in front of the residence as represented by Item 8. Consequently, the dirt road in front of the residence as represented by Item 8 cannot be eliminated as a possible source of the soil from the debris from the shoes (Items 1 and 2) (an inclusion, see interpretation section, below).

Exclusion:

Soil recovered from the debris from the shoes (Items 1 and 2) is different than the soil recovered from the grave site as represented by Item 7. Therefore, the grave site as represented by Item 7 is eliminated as a source of the soil on the shoes (Items 1 and 2) (an exclusion, see interpretation section, below).

Inconclusive

Debris recovered from the slippers (Items 3 and 4) contains insufficient geologic material for comparison to the grave site (Item 7) and dirt road (Item 8). No conclusion can be reached as to whether or not the debris recovered from the slippers (Items 3 and 4) originated from the grave site or dirt road (Items 7 and 8, respectively) (inconclusive, see interpretation section, below).

Example of an anthropology examination:

Inventory/Bone Identification

Items 9 and 10 are bones of non-human in origin, and no further anthropological examinations were conducted on those items.

Item 11 consists of images reported to originate from Jane Johnson.

Items 1 through 8 are bones of human origin and are identified below by element and side (where applicable):

Item 1 Cranium
Item 2 Mandible (lower jaw bone)
Item 3 Femur (upper leg bone), right
Item 4 Tibia (lower leg bone), right
Item 5 Scapula (shoulder blade), right
Item 6 Os coxa (hip bone), left
Item 7 Os coxa (hip bone), right
Item 8 Clavicle (collar bone), left

Biological Profile

The following biological parameters were estimated from the human skeletal remains:

Sex: Female
Ancestry: European
Age: 23-27 years
Stature: 63-67 inches (95 prediction interval)

The estimate of female sex was based on the female morphology of Item 6 and Item7 (including wide sciatic notches, a large subpubic angle, and the presence of a preauricular sulcus), small femoral head diameter of Item 3 (43mm), and overall small size and small muscle attachments of Items 1 through 8. European ancestry was estimated based on cranial measurements analyzed using FORDISC 3.0 comparing it to females of several ancestries. When compared to females of European, African American, and American Indian ancestry, FORDISC indicates a 0.90 posterior probability of European ancestry, while the posterior probabilities were much lower for being African (0.05), or American Indian (0.05). Skeletal maturation of Items 1 through 7 is complete, but Item 8 is in the final stages of epiphyseal union indicating an age of 23-27 years. Pubic symphyseal morphology of Items 6 and 7 also supports a relatively young age. Stature was estimated using FORDISC-assisted analysis of measurements of Item 3 and Item 4 using a European female reference.

Trauma

Bilateral perforations of the Item 1 cranium suggest alteration by a high velocity projectile such as a bullet. Radiographs of Item 1 were negative for radioopacities consistent with the presence of foreign material. The relative sizes of the perforations and the direction of beveling indicate projectile entry on the left side and exit on the right. The absence of bone remodeling (healing) as well as the nature and pattern of missing bone and associated fractures suggest that the trauma occurred perimortem (at or around the time of death). Perimortem timing of trauma is determined on the basis of evidence of the biomechanical characteristics of fresh bone regardless of the temporal relationship to the actual death event. No additional trauma was noted.

Identification Comparison

The biological information reported for Jane Johnson, a 26-year old, 5'4" white female, is consistent with the biological profile above (that is, the information on Jane Johnson falls within the range of the biological profile estimated from the skeletal remains). Anterior-posterior radiographs taken of Item 1 were compared to the images contained in Item 11. The quality and quantity of shared details of the radiographic images from the Item 1 cranium and the Item 11 images from Jane Johnson indicate that Jane Johnson can be included as the source of Item 1.

Appendix C: *Examples of Appropriate Wording for the Interpretations/Limitations Section of a Trace Evidence Report*

Example of a hair examination and comparison:

Hairs may be characterized and classified according to their morphology. The first step is determining whether the hair is of human or animal (non-human) origin. Animal hairs may be further classified as to the type of hair (*e.g.*, fur, guard) and the type of animal (*e.g.*, dog, cat). Human hairs may be further examined for characteristics of ancestry and somatic origin (body area). Human hairs can exhibit characteristics of European Ancestry (previously Caucasian), African Ancestry (previously Negroid), or Asian/Native American Ancestry (previously Mongoloid). Human hairs may also exhibit characteristics of more than one ancestral group. Ancestral group classifications are based on macroscopic and microscopic characteristics which are typically observed in hairs from individuals of different ancestral groups. It should be noted, there is the potential for a hair to be classified into an ancestral group which may not correspond with an individual's outward physical appearance and/or how an individual identifies their own race or ethnic group. Somatic origin classifications are based on the macroscopic and microscopic characteristics which are typically observed in hairs from different areas of the body.

The characteristics exhibited in the hair(s) are used as the comparison criteria. When the presence or absence, appearance, and distribution of characteristics exhibited in a recovered hair(s) are represented in the known sample, the source of the known sample can be included as a possible source of the recovered hair(s). Microscopic hair comparisons are meaningful due to the variation in macroscopic and microscopic characteristics between individuals. However, the comparison of hair characteristics does not constitute a basis for personal identification and the number of individuals who could be included as a possible source of a specific hair is unknown.

The inability to associate persons/items through a microscopic hair/fiber examination does not necessarily mean the persons/items of interest had no contact. A number of factors can produce this result, including: 1) Hair/fiber evidence may not have transferred. 2) Hairs/fibers that did transfer may have been lost prior to submission to the laboratory. 3) The hairs/fibers transferred or the known sample submitted may not be representative of the source. 4) The hairs/fibers may be from a different source.

Example of a fiber examination and comparison:

Fibers can differ as to type (*e.g.,* rayon, cotton), color, shape, size, microscopic features (*e.g.,* delustrant, voids) and optical properties (*e.g.,* refractive index, sign of elongation). These are characteristics that may associate fibers with a group of items, but never to a single item to the exclusion of all others. However, even fibers with many similar properties may be excluded as originating from the same source by using the identified analytical methods.

The characteristics and optical properties of the fiber(s) are used as comparison criteria. When the characteristics and optical properties of a recovered fiber(s) are the same as a known sample,

the recovered fibers are consistent with originating from the source of the known sample, or from another item comprised of fibers that exhibit the same microscopic characteristics and optical properties. A fiber association is not a means of positive identification and the number of possible sources for a specific fiber is unknown. However, due to the variability in manufacturing, dyeing, and consumer use, one would not expect to encounter a fiber selected at random to be consistent with a particular item.

The inability to associate persons/items through a microscopic hair/fiber examination does not necessarily mean the persons/items of interest had no contact. A number of factors can produce this result, including: 1) Hair/fiber evidence may not have transferred. 2) Hairs/fibers that did transfer may have been lost prior to submission to the laboratory. 3) The hairs/fibers transferred or the known sample submitted may not be representative of the source. 4) The hairs/fibers may be from a different source.

Example for a fabric examination and comparison (used in conjunction with fiber interpretation):

A fabric examination begins with the characterization of the construction (e.g., woven, knit, non-woven) and an analysis of the fibers comprising the fabric. When all of the characteristics present in a fabric sample (color, construction and composition) are the same as another fabric sample, the possibility that the compared fabrics originated from the same source cannot be excluded.

Example for a cordage examination and comparison (used in conjunction with fiber interpretation):

An examination of cordage begins with the characterization of the construction (*e.g.,* twisted, braided) and an analysis of the fibers comprising the cordage. When all of the characteristics present in a cordage sample (color, construction and composition) are the same as in a potential source, the possibility that the compared cordage originated from the same source cannot be excluded.

Example for a fabric physical match:

Examination of fabrics for physical fits begins with the characterization of the construction of the fabric and an analysis of the type of damage present (*e.g*., cut, torn). The shape, appearance, and yarns along the damaged edges are used as criteria for comparison. When two or more pieces of fabric can be oriented so the size, shape, and appearance of the damaged edges can be uniquely correlated, it can be determined that the two pieces were at one time one continuous piece.

Example for a cordage physical match:

An examination of cordage for physical fit begins with the characterization of the construction of the cordage and an analysis of the type of damage present (*e.g*., cut, torn). The shape, appearance, and yarns along the damaged edges are used as criteria for comparison. When two or more pieces of cordage can be oriented so the size, shape, and appearance of the damaged edges

can be uniquely correlated, it can be determined that the two pieces were at one time one continuous piece.

Example of a glass examination and comparison:

If items do not physically fit together, they are compared based on their observed and measured properties. The possibility of a common origin is eliminated when any of the following criteria are met:

- The observed physical properties are different.
- The thickness of the recovered glass fragment falls outside the range of values measured in the exemplar glass.
- The average refractive index for a recovered glass fragment falls outside the range of values measured in the exemplar glass. This comparison is performed separately for each wavelength measured.
- The average concentration of each element for a recovered glass falls outside a modified 4σ confidence interval for the exemplar glass. A modified 4σ confidence interval is calculated by taking either the measured relative standard deviation for the concentration of each element in the exemplar or 3% of the average elemental concentration of each element measured in the exemplar, whichever is greater, and multiplying it by four. The confidence interval for each element is the average value of the elemental concentrations ± the modified 4σ. This comparison is performed separately for each elemental concentration measured.

When the physical properties assessed are not different, the average refractive index measurement of the recovered glass falls within in the range of the refractive index values of the exemplar glass, and the averages of the concentrations of all of the elements measured in the recovered glass falls within the modified 4σ interval of the exemplar glass, the glasses are said to be indistinguishable.

The variations in the observed and measured properties within a glass object are typically smaller than the variations among objects. Studies have shown that refractive index measured at 589 nm and elemental composition of glass used in conjunction are highly discriminating[1], differentiating most glass that is not the actual source. This finding strongly supports the supposition that a recovered glass fragment and a broken object with indistinguishable refractive index at 589 nm and elemental composition are unlikely to be from another source. While this finding is not a direct indicator of the rarity of a particular glass in any specific case, it can be used to show that the occurrence of coincidentally indistinguishable glass is rare. In glass items where only refractive index data can be measured, the chance of finding coincidentally indistinguishable glass is significantly higher.

[1]Koons, R. D. and Buscaglia, J. The forensic significance of glass composition and refractive index measurements, *Journal of Forensic Sciences* (1999) 44:496–503.

There are four possible conclusions when comparing glass fragments:

- Fracture Fit: The glass fragments were once part of the same broken object. This conclusion is an examiner's decision that two or more glass fragments show sufficient correspondence between their macro- and microscopic characteristics, providing extremely strong support for the proposition that they were once part of the same object; and insufficient disagreement between their macro-and microscopic characteristics, providing extremely weak support for the proposition that the glass fragments originated from different objects. This conclusion is reached when two or more pieces of broken glass physically fit together.

- Inclusion: The glass fragments either originated from the same broken glass source or from another source(s) of broken glass with indistinguishable characteristics. This conclusion may be reached with or without elemental composition.

    Inclusion with Elemental Composition Examination: If elemental composition data has been acquired, an examiner may conclude that two or more glass fragments either originated from the same broken glass source or from another source that is indistinguishable in all assessed physical characteristics, refractive index, and elemental composition. Such conclusions may include probabilities based on appropriate databases or documented frequencies.

    Inclusion with No Elemental Composition Examination: If elemental composition data has not been acquired, an examiner may conclude that two or more glass fragments either originated from the same broken glass source or from another source that is indistinguishable in all assessed physical characteristics and refractive index. Such conclusions may include probabilities based on appropriate databases or documented frequencies.

- Exclusion: The glass fragments are eliminated as originating from the same source(s). This conclusion is reached when two or more fragments of glass are different in their physical properties, refractive indices, or elemental concentrations.

- Inconclusive: The possible source(s) of broken glass cannot be determined. This conclusion is reached when the glass fragment is too limited in size or quality.

For additional information on forensic glass analysis and results interpretation, please see Almirall, Jose, and Tatiana Trejos, "Analysis of glass evidence," *Forensic Chemistry: Fundamentals and Applications* (2015): 228-272.

Limitations:

A forensic glass analysis is typically a comparison of two or more glass fragments in an attempt to determine if they originated from different sources. These analyses require the determination of class characteristics that may associate objects with a group of similar objects such as

containers, but never to a single object except in the case of a fracture fit. It is important to note, however, that although there may be several objects with identical properties, glass fragments can originate only from broken and not intact objects. Only when two or more broken glass fragments physically fit together can it be said that they were once part of the same object.

Example of a geologically-derived material examination and comparison:

Color, texture, and composition are used as comparison criteria when a sufficient quantity of soil for reliable and reproducible results is present. There are four possible conclusions when comparing geologically-derived material:

- Fracture Fit: The geologically-derived materials were once part of the same broken object. This conclusion can only be reached when two or more geologically derived materials physically fit together.
- Inclusion: The possibility that the geologically-derived (s) originated from the same source as the geologically-derived material collected from a known location (exemplar) cannot be eliminated. Additional geologically-derived material(s) that are indistinguishable in all assessed characteristics could also be potential sources. This conclusion is reached when the material(s) cannot be differentiated from the exemplar using all observed or measured characteristics, there is sufficient quantity of material for reliable and reproducible results, and no inseparable mixing or deleterious change is indicated.
- Inconclusive: No conclusion can be reached on whether or not the soils could have originated from the same source. This conclusion can be reached for several reasons, including insufficient quantity for either the soil item or exemplar, when there is inseparable mixing with other sources of geologic materials, or when there has been deleterious change of the item(s) or exemplar.
- Exclusion: The possibility that the item(s) originated from the same source as the exemplar is eliminated. This conclusion is reached when the item(s) can be differentiated from the exemplar, there is sufficient quantity of material for reliable and reproducible results, and no inseparable mixing or deleterious change is indicated.

Soil properties vary both across the land and below the land surface as a function of parent material, climate, biological activity, geography, and time, yielding soil which is distinct from location to location and with depth below the surface. These changes can occur abruptly or gradually. Therefore, the exemplar soils from a specific site must be interpreted to represent only that site, and may not be representative of all soils in the area or soil that may have been present in the past.

Limitations:

Due to the possible variations in soil, the boundaries of a homogeneous soil cannot be predicted with absolute certainty. Soil and geologic studies and maps of an area may assist in defining the approximate extent of a homogeneous soil.

When debris from an item is eliminated as originating from an exemplar location through a soil comparison, no inference can be made as to whether or not the item was present at that location. A number of factors can produce this results, including:

- The material did not originate from the location in question.

- No material was transferred from the location to the item.
- Material which may have transferred from the location to the item was not preserved.
- Additional material may have transferred at some other time which mixed into the material on the item(s).
- The exemplars from the location in question so not adequately represent that location.

A geologically-derived materials analysis is typically a comparison of two or more geologically-derived materials in an attempt to determine if they originated from different sources. These analyses require the determination of class characteristics that may associate objects within a group of similar objects such as a particular variety of wallboard from a specific manufacturer, but never to a single object except for a fracture fit. Only when two or more broken fragments of geologically-derived materials physically fit together can it be said that they were once part of the same object.

Example of an anthropology examination:

Limitations:

The conclusions that can be reached from anthropological examination of skeletal remains are dependent on the condition and completeness of the skeletal material. Results based on fragmentary or poorly preserved material may be inconclusive.

From studies of known individuals, suites of traits as well as metric relationships are understood to characterize certain groups; however, due to variation within the human species due to both genetic and external factors (such as diet and lifestyle), no particular feature or measurement is considered diagnostic of membership in any one particular group. Due to differences in ancestral reporting standards, possible matches with individuals of ancestries other than those reported should not be excluded without further investigation.

Studies of skeletal trauma have revealed patterns that show relationships with certain known causes and that are governed by bone biomechanical properties; however, due to the variety and complexity of factors that may contribute to disruption of skeletal tissues, it is not always possible to determine trauma mechanism or timing with certainty.

Identification comparisons involve assessment of the similarity of antemortem and postmortem skeletal information. The more distinctive or unusual the shared characteristics, or the greater the number of shared features, the more likely it is that the two originated from the same person. The strength of the correspondence may be reported based on reference to documented frequencies of particular skeletal conditions or features, if known. Identification comparisons may result in one of the following conclusions:

- *Inclusion*

'Inclusion' is an examiner's conclusion that the questioned skeletal information could have originated from the same individual as the known skeletal information, or from another source with the same skeletal features.

The basis for an 'inclusion' conclusion is an examiner's opinion that there is sufficient agreement between the features of the questioned and known skeletal information, with no unexplainable differences, to conclude that the skeletal information could have originated from the same source or from another source with the same skeletal features.

The strength of the agreement, based on relevant databases or published frequencies of shared skeletal feature(s), shall be reported, if known. If the frequency of the shared feature(s) is not known, the examiner shall disclose that the number of individuals who may also share the feature(s) is unknown.

- *Exclusion*

‘Exclusion’ is an examiner’s conclusion that the questioned and known skeletal information could not have originated from the same source.

The basis for an ‘exclusion’ conclusion is an examiner’s opinion that the questioned and known skeletal information exhibit sufficient differences in skeletal features such that the questioned skeletal information could not have originated from the same source as the known skeletal information.

- *Inconclusive*

‘Inconclusive’ is an examiner’s conclusion that no determination can be reached as to whether the questioned and known skeletal information could have originated from the same source.

The basis for an ‘inconclusive’ conclusion is an examiner’s opinion that there is insufficient quantity and/or quality of skeletal features in the known and/or questioned skeletal information to determine whether the skeletal information could have originated from the same source or from another source with the same skeletal features.